GRASSROOTS JOURNALS

Grassroots Journal of Natural Resources, Vol.8 No.3 (December 2025)
ISSN: 2581-6853 | CODEN: GJNRA9 | Published by The Grassroots Institute
Website: https://grassrootsjournals.org/gjnr | Main Indexing: WoS, CABELL, EBSCO

ISSN 2581-6853 | 8(3) December 2025

00614 | Review & Analytical Article

Ecosystemicity as a Vector of Sustainable Management in the Landscape of New Paradigms of Social Development

Nina Berezovska*[1], Volodymyr Zahorskyi[2], Nadiia Kalashnyk[3], Andriy Lipentsev[4], Larysa Novak-Kalyayeva[5], Olha Oilefirenko[6], Volodymyr Oliyarnyk[7], Oleksandr Sushynskyi[8]

[1]National Forestry University of Ukraine, Lviv, Ukraine.
Email: berezovska@nltu.edu.ua | ORCID: https://orcid.org/0000-0003-4628-2958
[2]National Forestry University of Ukraine, Lviv, Ukraine.
Email: volodymyr.zahorsky@nltu.edu.ua | ORCID: https://orcid.org/0000-0003-3260-3271
[3]National Forestry University of Ukraine, Lviv, Ukraine.
Email: nadiia.kalashnyk@nltu.edu.ua | ORCID: https://orcid.org/0000-0003-0814-0246
[4]National Forestry University of Ukraine, Lviv, Ukraine.
Email: lipentsev1@gmail.com | ORCID: https://orcid.org/0000-0001-8960-3059
[5]National Forestry University of Ukraine, Lviv, Ukraine.
Email: larysa.novak-kalyayeva@nltu.edu.ua | ORCID: https://orcid.org/0000-0002-2897-8858
[6]National Forestry University of Ukraine, Lviv, Ukraine.
Email: olefirenko@nltu.edu.ua | ORCID: https://orcid.org/0000-0002-8296-3497
[7]National Forestry University of Ukraine, Lviv, Ukraine.
Email: volodymyr.oliyarnyk@nltu.edu.ua | ORCID: https://orcid.org/0009-0008-3621-1949
[8]National Forestry University of Ukraine, Lviv, Ukraine.
Email: oleksandr.suszynskyi@nltu.edu.ua | ORCID: https://orcid.org/0000-0002-3213-5976
**Corresponding author*

How to cite this paper: Berezovska, N., Zahorskyi, V., Kalashnyk, N., Lipentsev, A., Novak-Kalyayeva, L., Oilefirenko, O., Oliyarnyk, V. and Sushynskyi, O. (2025). Ecosystemicity as a Vector of Sustainable Management in the Landscape of New Paradigms of Social Development. *Grassroots Journal of Natural Resources*, 8(3): 344-366. Doi: https://doi.org/10.33002/nr2581.6853.080314

Received: 14 October 2025
Reviewed: 24 November 2025
Provisionally Accepted: 25 November 2025
Revised: 30 November 2025
Finally Accepted: 02 December 2025
Published: 31 December 2025
Copyright © 2025 by author(s)

Publisher's Note: We stay neutral with regard to jurisdictional claims in published maps, permissions taken by authors and institutional affiliations.

This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/4.0/

Open Access

Executive Chief Editor
Dr. Hasrat Arjjumend
Assistant Managing Editor
Mr. Kartik Omanakuttan
Associate Editors
Dr. Usongo Patience
Dr. Nivedita Chaudhary

Abstract

Understanding the linkages between social and natural systems is critical for efficient management and the implementation of sustainable development. However, contemporary discourse reveals a persistent over-economization of sustainable development, characterized by excessive emphasis on financial indicators and economic performance. This can obscure or compromise the sustainability movement's larger social and environmental goals. This paper analyzes the role of the ecological component of sustainable development (SD) in relation to emerging paradigms of social development using the concept of 'ecosystemicity', and outlines prospects and applications of this concept. Using a narrative review of literature retrieved primarily via Semantic Scholar, the study identifies imbalances in SD conceptualization and practice, particularly a bias toward economic growth and metrics at the expense of social well-being and ecological integrity. The findings revealed imbalances in the current SD conceptualization and practical manifestations, namely, a bias towards economic growth and economic indices, to the detriment of social and especially ecological domains. This imbalance is present even in the indicators of SDGs as a foundation of the overall SD landscape, both globally and at the national and local levels. These imbalances are evident not only in policy and practice but also embedded within the indicators of the Sustainable Development Goals (SDGs), which shape global, national, and local development trajectories.

Keywords

Development perspectives; Ecological domain; Management decisions; Over-economization of SD; Public management and administration; Resources; SDGs; Socio-economic development; Sustainable development

Introduction

Sustainable management seeks to meet present needs without compromising future generations' ability to meet theirs. Achieving this objective requires a balanced integration of social inclusion, economic advancement, and environmental conservation. Central elements include poverty reduction, equitable resource access, environmental stewardship, and integration of ecological perspectives into policy and decision-making. These priorities are reflected in the United Nations' 17 Sustainable Development Goals (SDGs), which emphasize partnerships, inclusivity, and collaborative actions as foundations for a sustainable future.

Table 1 summarizes intersections between core SD principles and priorities of emerging social development paradigms These paradigms emphasize eliminating extreme poverty, reducing inequalities, ensuring access to quality healthcare and education, promoting environmental responsibility, and expanding corporate social responsibility through innovative and energy-efficient solutions (Barron *et al*., 2023; Berezovska *et al*., 2024; Hessle, 2014; Wyrwa *et al*., 2023).

Table 1: Sustainable development and new social development: intersection

SD Key Principles	Important Elements of the New Social Development	Reaching Long-Term (Sustainable) Social Progress
Three interrelated pillars: economic success, social inclusion, and environmental protection, form the foundation of sustainable development.	Eliminating extreme poverty in all of its manifestations and aspects is a primary goal.	The 17 Sustainable Development Goals (SDGs) set forth by the UN provide a thorough road map for attaining a sustainable future that is relevant to all countries.
Meeting present demands: Developing in a way that meets the demands of the present generation is the main objective.	Decreased inequities: Fair development requires addressing inequities and encouraging social inclusion. Quality Healthcare & Education: It is essential to guarantee access to basic services and high-quality education.	Systemic Integration: Rather than treating economic, social, and ecological issues separately, sustainable management necessitates a paradigm change.
Preserving Future Generations: Development must ensure that resource availability and quality are maintained without compromising the capacity of future generations to meet their own requirements.	Environmental Stewardship: It is essential to incorporate ecological viewpoints and manage ecosystems and natural resources sustainably.	Multi-Stakeholder Partnerships: Governments, corporations, civil society, and individuals must work together in concert to achieve these objectives.

Organizations and businesses are urged to embrace social responsibility and include sustainable practices in their management plans.	Innovation in Technology: Fostering innovation and increasing the ability to create new energy sources and boost energy efficiency contribute to sustainable growth.	Corporate Social Responsibility (CSR): Businesses are embracing the idea of CSR more and more in order to support social well-being and make investments in the sustainable development of society.

Source: Barron *et al*. (2023); Berezovska *et al*. (2024); Hessle (2014); Wyrwa *et al*. (2023)

Despite this agenda, concerns have grown over the marginalization of the ecological dimension of sustainable development. Increasingly, the economic component dominates both academic discourse and practical implementation. Ilic and Dukic (2022), for example, emphasize management's role in economic recovery and the need for learning-oriented, innovation-driven societies. Although their arguments are valuable, such perspectives risk further overshadowing ecological imperatives.

Sedovs, Volkova and Ludviga (2025) identify major obstacles to achieving the UN 2030 Agenda. Despite this increased awareness of sustainability, recent UN assessments show that there hasn't been enough progress on this issue. One of the main drivers of a sustainable economy is innovation, which is characterized as significant advancements or changes in the environment, behavior, and economy that reflect bigger paradigm shifts in society and the economy. Wu *et al*. (2025) stress that place-based solutions that balance local realities with global aspirations are necessary to achieve the Sustainable Development Goals. A crucial size area that is both sufficiently grounded to allow for context-sensitive understanding and regulation and broad enough to encompass cross-border biological and socioeconomic processes is represented by landscapes and regions.

Another bright example of shifting the accents of SD is seen in the work of Hariram *et al*. (2023). According to the authors, a holistic approach is required, and this serves as the foundation for a new development paradigm known as sustainability. This study presents a new socioeconomic theory of sustainability that emphasizes quality of life, social fairness, culture, global peace, social justice, and well-being. The authors define 'sustainalists' as those who accept these new ideas.

Meanwhile, critics correctly point out that the sustainable development framework is insufficiently ambitious to handle the scope and urgency of today's environmental and social concerns. Some argue that emphasis on economic growth and development might perpetuate unsustainable natural resource use as well as unequal income and power distribution (Ketschau, 2017). The term "overeconomization of sustainable development" refers to a criticism that the economic growth model, even with sustainable aims, continues to put economic measures ahead of actual ecological and social well-being, creating an unsustainable system (Dai *et al*., 2024). This approach often relies on market-based solutions, efficiency improvements, and the circular economy without fundamentally challenging the paradigm of endless consumption, which is incompatible with the planet's

finite resources. Critics argue it can mask inequalities and focus on "disembedded" economic systems rather than embedded social and natural ones.

According to Horodecka (2023), economics is moving away from interdisciplinary integration, marginalizing social and ecological issues, and promoting a segmented understanding of development that prioritizes market mechanisms above overall well-being. The consensus is that putting economic factors first promotes general well-being, the achievement of social goals, and more resource allocation to ecological objectives, all of which support sustainable development. This viewpoint has been challenged by a number of writers, who contend that depending solely on the prevailing framework for economic policy does not produce long-term results. Instead of treating social and ecological aspects as distinct entities, these critical voices support an all-encompassing strategy that incorporates them into the framework of economic development.

As Eisenmenger *et al*. (2020) correctly point out, SDGs prioritize economic growth over sustainable resource usage. The authors integrate empirical insights from social ecology into assessments of SDG targets and indicators. They discovered that the SDGs fail to track absolute changes in resource use, prioritizing economic growth over environmental integrity. Secondly, they address the conflicts between economic growth and sustainable resource use in the early and late stages of industrialization processes, demonstrating that they are accountable for significant trade-offs among SDG targets. These limitations indicate the need to reorient sustainable development towards its foundational ecological roots. However, given the complex and interconnected nature of contemporary environmental, social, and economic processes, the ecological domain must be approached from a systemic perspective. Achieving sustainable development requires more than the mere inclusion of 'sustainable goals' in the conventional understanding of economic development. Meanwhile, the research field on these issues is rather narrow and scattered. This paper, therefore, advances the concept of ecosystemicity, a framework that understands society and the environment as interdependent and dynamic systems.

An ecosystemic approach to sustainable development views human society and the environment as interrelated, dynamic systems, emphasizing the interdependence of human activities and ecological processes in order to attain comprehensive and long-term well-being for all (Kalashnyk and Kyrylenko, 2025). This approach goes beyond sectoral, linear thinking by acknowledging that actions have complex, systemic consequences. It advocates for integrated, place-based solutions that take into account people's values for ecosystem services while also promoting ecological consciousness and regenerative educational paradigms. At the same time, the term 'ecosystem' is applied not only in the natural resource sphere, but also in management, where an "ecosystem" refers to a "network of interconnected entities like companies, suppliers, and customers who collaborate to create and share value, particularly in a business context" (Dai *et al*., 2024). In turn, one of the main factors in such ecosystems' successful functioning is value creation, and understanding the configuration of business ecosystems requires understanding the specific elements of value co-creation (Betz and Jung, 2021). This approach seems valuable for the field of sustainable development, since integrating value creation concerns into the realm of the three SD areas (economic, social, and environmental) would allow achieving more balance between them. This is the essence of the ecosystematicity paradigm.

With this in mind, this study aims to outline the concept of ecosystemicity and its potential for enhancing sustainable management in the conditions of the current paradigm shifts in social development. This paper treats 'ecosystemicity' as a framework to redress those imbalances and to prevent entropy in the SDG landscape.

Materials and Methods

Sustainable development aims to balance social inclusion, economic progress, and environmental conservation. However, current global and national strategies increasingly prioritize economic dimensions at the expense of ecological integrity. This study adopts an integrative review methodology to examine the strengths and weaknesses of the SDGs and to explore the potential of ecosystemicity as a systemic framework for sustainability transformation. We selected an integrative review because it synthesizes conceptual, empirical, and theoretical sources to provide a comprehensive understanding of complex sustainability issues. Application of the integrative review methodology enables conceptual synthesis within the scope of research.

Data Sources

We sourced publications for the narrative review from ScienceDirect, Springer, Wiley, JSTOR, ResearchGate, Taylor & Francis Online, and Google Scholar. The databases were picked because they all provide a wealth of book chapters and peer-reviewed journal papers in a variety of subjects, including issues of sustainable development, its elements, and related fields. We used Semantic Scholar (https://www.semanticscholar.org/) to efficiently locate literature on SD paradigms (ecological, social, economic) and on policy and community implications. In addition to Semantic Scholar use, direct search in the Google search platform was applied (monographic works, international organizations/consulting companies reports, and statistical data). The following inquiries were used: *SDGs elements alignment, ecosystem theory, ecosystem approach, SD contemporary concepts, SD management, SDG and sustainable development, and SD evolution.*

Search Strategy and Selection Process

The initial search returned 256 publications; after removing duplicates and non-English items, 173 unique records remained for manual screening. In stage one, we screened topics and abstracts. The scope of studies was screened, and only those studies that are related directly to SDGs alignment/SD with a social component were chosen for further analysis. After narrowing the array of publications at the first stage, at the second stage of manual scoping, we analyzed methods and findings of publications based on their quality and relevance for the study. After detailed assessment, 39 publications were retained for final analysis.

Data Analysis

The selected literature was analyzed qualitatively by: identifying recurrent themes in SDG critiques, extracting theoretical insights from social ecology, assessing how sustainability debates incorporate or neglect ecological systems thinking, and synthesizing perspectives to develop the conceptual framing of ecosystemicity.

Selection Procedure

Figure 1 presents the PRISMA flow diagram of search, screening, and inclusion stages.

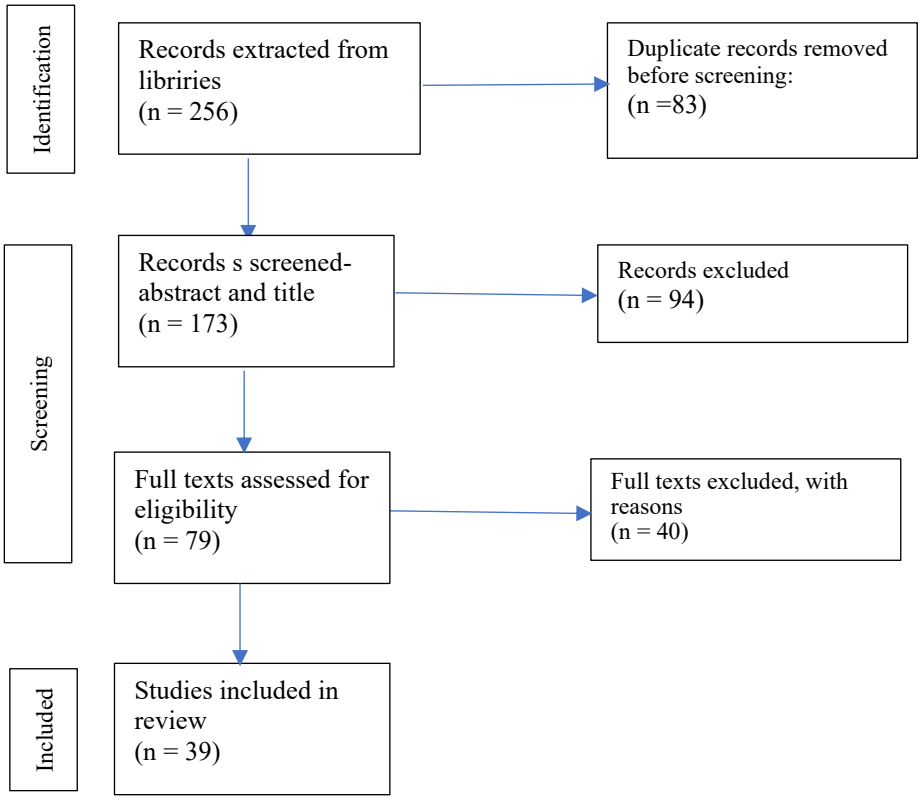
Identification
Records extracted from libriries (n = 256)
Duplicate records removed before screening: (n =83)
Screening
Records s screened- abstract and title (n = 173)
Records excluded (n = 94)
Full texts assessed for eligibility (n = 79)
Full texts excluded, with reasons (n = 40)
Included
Studies included in review (n = 39)

Figure 1: PRISMA flow diagram showing the selection criteria of studies

Results and Discussion

The early twenty-first century has seen unprecedented ecological shocks and systemic challenges driven by globalization and rapid technological change. The economic conditions that exist in practically every human effort, as well as the social norms and foundations that support human society, have been impacted by globalization (Zahorskyi *et al*., 2024). As population mobility peaked, the competitive advantages offered by conventional sources of production significantly leveled off. With accelerating technological innovation, a high degree of internationalization of social production, and increasing interdependence of national economies, the human race has reached a new stage of public manufacturing (Xu, 2024). Territorial management strategies must integrate ecological and social dimensions to respond to dynamic global changes. According to recent studies, adaptable methods that can address the difficulties brought about by global shifts while also taking into consideration the unique features of each region are required (Čábelková *et al*., 2023).

Ecological Living Conditions and Sustainable Rural Development

Li *et al*. (2021) investigated the relationship between ecological living conditions of inhabitants and sustainable rural development (SRD). The goal of the project was to develop an SRD index system based on the ecological well-being concept's methodological guidelines. Their findings support earlier conclusions and emphasize the improvement of ecological potential as a central focus. The idea of sustainable development for the areas they established presumed that an ecological component would be incorporated primarily. For example, Li *et al*. (2021) support the expansion of eco-friendly production, a green economy, an environmentally responsible manner of disposing of garbage, and the provision of a comprehensive variety of affordable utilities to the people of the region.

Copus, Kahila and Fritsch's (2022) comparison of urban and rural development viewpoints is another important study component. The authors have provided compelling evidence that rural development is significantly more profitable in the modern world than more urban expansion, based on an examination of rural development in Finland and Scotland. In the context of the COVID-19 epidemic and the post-COVID-19 economy, earlier researchers called city consolidation a "zombie idea", highlighting the peril of disregarding the function and importance of rural areas in the current economic climate (Jiang *et al*., 2022). According to Castro-Arce and Vanclay (2020), the research field of earlier publications is also much broader and tries to highlight the prospects for the development of rural lands in general. A recent analysis of the impact of transformational social innovations on rural sustainability is presented by Castro-Arce and Vanclay (2020). The success of management decision-making to ensure sustainable rural development is largely determined by social innovations, which have been previously researched by scholars in the context of inclusive planning to achieve sustainable rural development (Castro-Arce and Vanclay, 2020).

Integrated Potentials for Sustainable Territorial Development

In contrast, the study of Xu (2024) focuses on illustrating the necessity of integrated resource usage, social potential, and environmental potential in order to achieve sustainable territorial development, taking into account the prospects for the development of rural areas as given. According to the author, if the territory's social potential is diminished, it will be impossible to develop its resources and ecological potential sustainably. His research also shows that as the natural potential of the region declines, it is impossible to develop its resources and social potential in a sustainable manner.

Sustainable territorial development requires simultaneous use of social, resource, and environmental potentials. This assertion is supported by statistical evidence. Specifically, there has been resistance to incorporating population-related conversations into climate activism and education. However, population increase is closely related to climate change. Recent evidence shows that the rich are significantly more likely than the poor to emit more carbon dioxide, and that the poor are more likely than the rich to become victims of climate change (Benjamin, 2023). Income and per capita CO_2 emissions are clearly correlated at the national level, with the average emissions of those residing in major oil-producing countries and industrialized nations at the top of the

charts (Sarvajayakesavalu and Chareonsudjai, 2021). The bulk of the world's population resides in middle- and low-income countries, where emissions are significantly lower than those in the highest-income countries due to consumerist lifestyles and harmful production techniques (see Figures 2 and 3) (Singh and Batar, 2024).

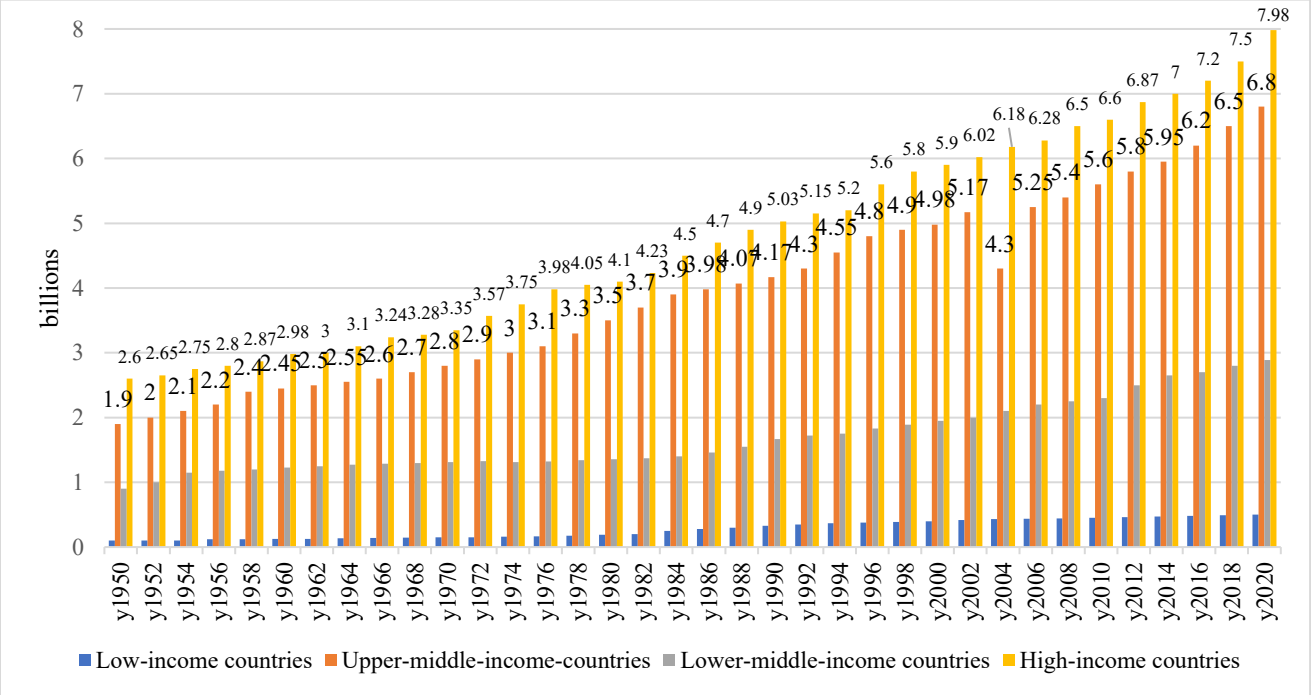

Figure 2: Global trends in population by income level [*Source*: Singh and Batar (2024)]

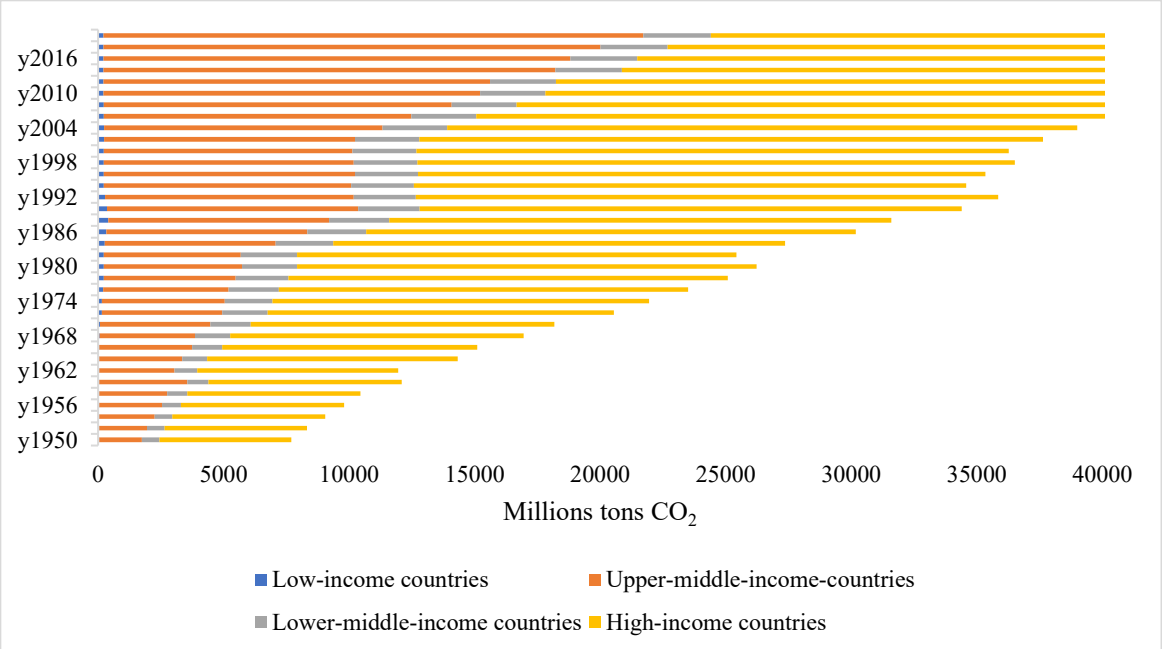

Figure 3: Carbon dioxide emissions by income level between 1950 and 2020 [*Source*: Singh and Batar (2024)]

Population pressures threaten food security, poverty alleviation, the preservation of natural resources, and the possibilities for human health, posing problems for both the environment and economic growth. The population of the world may increase to 8.5 billion people in 2030, 9.7 billion in 2050, and 10.3 billion in 2100, according to the UN's medium variation forecast (European Commission, 2022). The 46 Least Developed Countries (LDCs) are experiencing the quickest growth, with many of them expected to double in size by the middle of the century (Darling, 2021). Globally, it is evident that population expansion and climate sensitivity are linked. Land clearance brought on by population constraints in Pakistan has made floods worse while also pushing more people into flood-prone areas. Millions of people have been displaced from their homes in Afghanistan due to multi-year droughts that have exacerbated the country's continuous conflicts and economic collapse (Ahmed, 2021).

Stewardship, Virtuous Cycles, and Social–Ecological System Models

Ecosystems on Earth are essential to human existence, and in the Anthropocene, human activity is having a growing impact on ecosystems. Sustainability Effective environmental stewardship is essential to the long-term integrity of social-ecological systems, but present conceptual frameworks frequently lack empirical validation and have limited capacity to demonstrate progress toward sustainability goals. The study conducted by Turnbull, Clark, and Johnston (2021) looks at the ecological and social effects of local and institutional stewardship initiatives throughout 7000 km of Australia's coastline. The authors demonstrate how local and institutional stewardship together improve ecological outcomes, which in turn raise social values and inspire more stewardship, creating a positive feedback loop. They do this by using empirical mixed techniques and grounded theory. Turnbull, Clark, and Johnston (2021) illustrate virtuous cycles, which can span several iterations - in a new spiral model that makes it possible to visualize the advancement of sustainability objectives across time.

Managing the adverse effects of humans on the environment while explicitly acknowledging the reciprocal effects of environmental factors on humans is the main goal of the Human–Environment Systems (HES) framework (Scholz and Binder, 2011). HES facilitates the broad development of objectives and tactics to manage the human–environment connection and is based on decision theory, social sciences, and sustainability (Binder *et al*., 2013; Scholz and Binder, 2011). To assess the dynamics and environmental reactions resulting from these tactics, it simulates primary and secondary feedback loops. Although there is no sustainability component in the HES framework, it can be used to examine sustainability learning in a particular setting.

The Social-Ecological Systems Framework (SESF) treats social and ecological subsystems jointly but often adopts an anthropocentric view that frames ecological components as resources. This is seen in its use in the management of agriculture, fisheries, and water resources. It recognizes the governing system and resource "users", with feedback loops for social and ecological impacts resulting from system interactions. Like HES, SESF does not always explicitly embed a normative sustainability goal, though it can be used to assess social-ecological sustainability. The essence of these two frameworks is presented in table 2.

Table 2: SESF and HES frameworks: comparative detailing

Human–Environment Systems (HES) framework
Essence: HES is an interdisciplinary approach that emphasizes the interdependence and reciprocal influence of humans and the environment. By highlighting reciprocal feedback loops and the human role in causing environmental change, it goes beyond straightforward cause-and-effect to comprehend the intricate, co-evolutionary link between human civilizations and natural systems. The concept is essential to sustainability research, which looks for ways to improve human well-being while taking into account the planet's limited resources.
Core principles: - Complementarity: Human and environmental systems are interwoven, interdependent components of a whole rather than distinct entities. - Hierarchy and scale: Actions at one level have an effect on others at a variety of scales, ranging from personal decisions to international regulations. - Reciprocal interactions: The framework examines the ongoing feedback loops in which environmental changes influence human behavior, decision-making, and social structures, and human actions influence the environment. - Dynamic reactions: It recognizes that human behavior affects environmental systems in both immediate and delayed ways, sometimes resulting in sudden shifts or tipping points. - Human decision-making: From a decision-theoretic standpoint, human behavior is represented, including goal-setting, strategy selection, and action, all of which are impacted by environmental awareness.
Applications and goals: - Sustainability: By comprehending the intricate relationships that influence both human and environmental well-being, HES offers a foundation for building a more sustainable world. - Problem-solving: By combining social and ecological data to create practical knowledge, it helps resolve complicated environmental issues. - Policy and advocacy: The HES framework aids in promoting systemic changes, such as laws that encourage sustainable practices, by emphasizing the system rather than just individual acts. - Research methodology: It maps and measures the complex relationships within human-environment systems using a variety of techniques, such as remote sensing, ethnographic study, and complex systems modeling.
Social-Ecological Systems Framework (SESF)
Essence: SESF is an analytical tool developed by scholars like Elinor Ostrom to study the sustainability of natural resource systems by examining the complex interactions between human (social) and natural (ecological) components. It provides a structured, multi-layered approach with core components like resource systems, resource units, governance systems, and users (or actors) interacting within an "action situation". The framework helps researchers across disciplines understand feedback loops, dynamics, and collective action challenges to analyze system sustainability, equity, and resilience.

Core components: - Resource System: The actual location and the resource (such as a watershed, forest, or fisheries). - Resource Units: The distinct, discrete components of the resource system, such as the individual fish in a fishery or the trees in a forest. - Governance Systems: The institutions, procedures, and guidelines that control how resources are used and managed. - Actors (or Users): The people and organizations that make use of the resource and are impacted by the governance structure. - Action Situation: The particular setting in which actors decide and behave in ways that have an impact on the resource.
Key features and applications: - Multi-level and nested: The concept acknowledge arrangement in several levels, ranging from social and ecological contexts to individual interactions. - Interdisciplinary: It provides experts from various disciplines (such as ecology, economics, and political science) with a common vocabulary to collaborate on challenging issues. - Examines feedback loops: It draws attention to the feedback loops that link ecological and social systems, which can either boost or lower the system's ability to adapt. - Emphasis on sustainability: Its main objective is to offer a methodical approach to examining what makes a SESF robust, resilient, and sustainable in the face of change. - Practical application: It is used to diagnose issues with the management of natural resources, including those about the “commons”, and to guide research and policy.

Source: Benjamin (2023)

Partelow *et al*. (2019) characterize SESF as a useful instrument for facilitating information exchange and deliberative processes in community-based natural resource co-management contexts. As a result, the HES framework contributes to the development of integrated solutions that take into account ecological, social, and economic concerns. The HES framework envisions a symbiotic relationship between human and environmental systems. The human and environmental systems are viewed as two distinct systems with essential dependencies and reciprocal endorsement (Nagel and Partelow, 2022). Although both frameworks are valuable, they lack an explicit mechanism for integrating competing interests and values; ecosystemicity aims to provide such a value-integration concept.

The founding context, perspective, and assumptions for each of the above frameworks are evident in their distinctive vocabulary and constraints, which frequently result in a focus on the negative or exploitative aspects of the human–environment connection. Turnbull, Clark and Johnston (2021) want to create a model based on empirical evidence that emphasizes the positive activities that humans may take to promote upward trajectories in both environmental health and human well-being. This virtuous circle or cycle has the potential to serve as the foundation for such a model; nevertheless, it has been employed in a variety of ways, some of which differ, in both academic and business literature.

Tidball *et al*. (2017) used virtuous and vicious cycles to explore the concept of resilience in social-ecological systems. They applied systems theory, which holds that positive feedback enhances change while negative feedback inhibits or counterbalances it. Virtuous and vicious cycles were thus positive or reinforcing feedback loops that steered the system in desirable or undesired directions. In terms of sustainability, the distinction between desirable and undesirable is value-laden (Preiser, Pereira and Biggs, 2017). For instance, the preservation or loss of endemic biodiversity and the improvement or decline in human well-being could be examples of this. With a bifurcation zone that can tilt in either direction based on managerial and policy choices, the authors categorized good states in the virtuous domain and undesirable states in the vicious domain. They urged further study to pinpoint the behaviors that support positive cycles and provide evidence of the social and environmental repercussions.

The relationship between ecosystems and human well-being is a comprehensive cycle that can be either positive (virtuous) or negative, according to Masterson *et al*. (2019). Effective stewardship creates the positive cycle, whereas poor management and overexploitation of the environment create the negative cycle. The model acknowledges the role of institutions and policies in the cycle while incorporating human values, attitudes, and behaviors. Human benefits are sometimes thought of as a "basket" that includes experiences, financial gain, and direct use. The authors request more empirical research to better understand and validate cycle components in their presentation of this wide conceptual model.

Ecological Transition and the SDGs: Challenges of Over-Economization

The process of technical innovation to bring about social transformation while taking environmental sustainability standards into account is known as the ecological transition. The concept of sustainable development in its economic, social, and environmental components is central to the UN 2030 Agenda (Rotondo *et al*., 2022). The several goals include managing forests by halting desertification, protecting the oceans, seas, and marine resources, and taking immediate ecological action to fight climate change. Below, some key points to ensure the ecological transition are presented:

1. Renewable energy sources: European goals cannot even be met without a rise in investments in energy sources that respect natural resources and do not pollute or deplete them.
2. Using electricity to move around is known as electric mobility. One of the primary causes of air pollution is the transportation industry. It is necessary to make significant investments in urban, regional, and electric transportation mobility if aiming to meet the target of 6 million electric vehicles by 2030.
3. Utilizing cutting-edge digital technologies throughout the energy supply chain is known as "digital energy".
4. Energy storage, which refers to both energy storage and storage to increase energy efficiency.
5. Smart building: it refers to the creation of buildings in which energy efficiency systems are intelligently and automatically managed.
6. Circular economy: an economy meant to replenish itself, with all waste viewed as resources and no waste. A new perspective on production, consumption, waste, and logistics.

7. Agroecological model: increasing the area set aside for organic farming while reducing the usage of pesticides. To lessen emissions and their effects on the environment and human health, the intensive farming system must be changed.

Twenty-nine SDG indicators address planetary boundaries in physical units, supplemented by six GDP-relative efficiency indicators (e.g., resource productivity and resource intensity). Such efficiency indicators are frequently used in policymaking since they allow for the simultaneous handling of two issues, namely a prosperous economy and reduced environmental pressure. However, the nature of intense indicators is the loss of information regarding the two underlying absolute values. Resource-efficiency metrics can improve even if absolute resource use rises, provided GDP grows faster, thus masking absolute environmental pressures. Given the biophysical limits of natural resources and global sink capacities, efficiency indices alone are insufficient for tracking progress toward ecological sustainability (Eisenmenger *et al*., 2020). In broader societal terms, eleven of the seventeen SDGs reflect stewardship or benefit from ecosystem services and thus align with elements of the virtuous cycle (Table 3). Lastly, Fioramonti, Coscieme and Mortensen (2019) believe that the transition from evil to virtue is "essential to the 2030 Agenda's implementation".

Table 3: SDG components related to the virtuous cycle: humans caring for or benefiting from the environment (stewardship, social values, or ecosystem services, respectively).

SDG Goal No.	*Goal description*	*Stewardship components*	*Social values and service components*
1.	No poverty	-	Access to natural resources
2.	Zero hunger	Providing ecosystems maintaining	Sustainable food production
5.	Gender equality	-	Access to natural resources
6.	Clean water and sanitation	Protect and repair water-related ecosystems	-
8.	Decent work and economic growth	Separate economic growth from environmental damage	-
9.	Industry, innovation, and infrastructure	Increased usage of clean and ecologically friendly technology	-
11.	Sustainable cities and communities	Protect the world's natural heritage	Accessible green spaces
12.	Responsible consumption and production	Sustainable management of natural resources Environmentally responsible waste management	Utilizing natural resources effectively Living in balance with the environment
13.	Climate action	Meaningful mitigation	Adaptability to climate-related risks

14.	Life below water	Preserve and safeguard marine and coastal environments Diminishing marine pollution Stop unsustainable fishing techniques Preserve at least 10% of coastal and marine areas Expand scientific understanding to promote ocean health Promote conservation through international legislation	Sustainable utilization of healthy, productive oceans Increase the benefits of marine resources for small and less-developed nations Impact of marine biodiversity on development Access for small-scale artisanal fishers
15.	Life on land	Preserve and repair terrestrial ecosystems Preserve and prevent biodiversity loss Save endangered species Lessen the invading species' effects Increase reforestation and stop deforestation Fight against land deterioration and desertification	Utilizing terrestrial ecosystems sustainably Increased ability to reap the benefits of natural environments Benefits of genetic resources that are just and equal Integrate environmental and biodiversity values into planning and development pursue sustainable livelihood options

Source: Alvarez *et al*. (2025); Barbier and Burgess (2021)

Meanwhile, conventional social-ecological and virtuous cycle models can only partially visualize such transformations. They often focus on the interaction of components in the social-ecological system, but they do not immediately incorporate the concept of sustainability or allow for the depiction of positive progress toward sustainability over time. In this vein, a model suggested by Turnbull, Clark, and Johnston (2021) is of special interest. The sustainability spiral model depicts a conceptual picture in which the people-policy sub-cycle empowers local stewardship and enhances the effectiveness of institutional stewardship, which together drive ecological outcomes in the primary social-ecological virtuous cycle. Ecological outcomes lead to increased ecosystem services and values, which encourage greater management. The spiral model depicts several cycles of the virtuous cycle over time, advancing toward sustainability goals.

At a more specific level, like a specific SDG or objective, the Sustainability Spiral makes it possible to see the trajectory of advancement and the current state of sustainability. For instance, 10% of marine and coastal habitats must be protected by 2020 as part of the Life Below Water (SDG 14) aim. By setting the 10% target at the top of the spiral and recording the current position on the vertical dimension at various periods in time,

the Sustainability Spiral can be used for this one component alone. The model then promotes the development of the necessary stewardship actions (e.g., measures to expand the protected ocean area and facilitate support from the local community) as well as the values and ecosystem services that drive progress toward the objective (e.g., increased fish biomass and diversity, sustainable protein supply, and tourism income).

In the area of local settings, it is also useful to bring up a study by Wu *et al*. (2023)[1], who proposed calculating a composite ecological development index (CEI) to characterize the sustainability of social-ecological systems development using a multi-indicator analysis technique. The size of the index has a favorable correlation with the sustainable trend of regional development. This is how the CEI is computed.

$$CEIj = \sum_{i=1}^{n} y_{ij} * w_i \quad (1)$$

$$y_{ij} = x_{ij}(t+1) - x_{ij}(t) \quad (2)$$

Where CEI_j when the composite development index of city j. y_{ij} is the variation of indicator i in city j during the study period. Before computing the *CEI*, Wu *et al*. (2023) normalized y_{ij} to the interval [0, 1] using the range method to prevent distortion from differing indicator scales. The weights of individual indicators w_i are then derived by the entropy weighting method. $x_{ij(t+1)}$ is the value of indicator i in city j at the end of the study period, and $x_{ij(t)}$ is the value of indicator i in city j at the beginning of the study period. The authors' conclusion that the same causes drive social-ecosystem development differently in different regions is based on empirical testing of the suggested methodology.

Naturally, such balancing social development and ecological resilience within a systemic approach ultimately will lead to enhancing indices of the third element of sustainable development - economic domain. And vice versa, starting SD efforts from the economic viewpoint, laying down first of all economic vision in the foundation of SD inevitably leads to dominance of economic rationality perspectives in SD decision-making, behavior, and policies design, often to the detriment of social and ecological factors. Sometimes, sustainable development is presented solely as a means of 'making money', improving reputation and goodwill, which can cause people to prioritize profitable "green" or "impact" investments over those that are most important for social or ecological well-being. Even when adjusted to take sustainability into consideration, a strong dependence on economic metrics such as GDP might overlook environmental harm and non-monetary well-being. This list of negative manifestations of over-economization of SD can be continued with multiple entries. But to combat appropriate imbalances, ecosystemicity as a vector of sustainable management seems a promising solution in the conditions of emerging paradigms of social development.

Given that the separation of social and ecological systems as distinct entities is no longer deemed appropriate, development must include social justice (social system) and environmental protection (ecological system) as fundamental components. These objectives are critical to the efficient operation of the economic system. Failure to

[1] The method is given for illustrative purpose

address these challenges in development strategies may lead to a reduction in economic development, as illustrated by the effects of climate risks (Horodecka, 2023). However, such an approach is still unsatisfactory since it limits discourse to the interplay of discrete variables from imagined, separately hypothesized systems, rather than understanding the economy broadly as a system embedded in the social and ecological ones, with all the repercussions. In this vein, ecosystemicity allows tracing the 'value chain' and enables value creation, suitable for all stakeholders, that is, 'representatives' of all three elements of the SD framework.

Toward Ecosystemicity as a Vector for Sustainable Management

The evidence across studies points to the need for an integrated, systemic approach to sustainability, one that fully recognizes the interdependence of social, ecological, and economic dimensions. While existing frameworks capture aspects of human–environment interactions, they fall short in visualizing long-term sustainability trajectories or embedding ecological primacy. Here, ecosystemicity emerges as a promising framework and vector for sustainable management. By centering ecological integrity and systemic interconnections, ecosystemicity transcends the limitations of economically driven models. It emphasizes the dynamic integration of social, ecological, and resource potentials; local and institutional stewardship; recognition of positive feedback cycles; and alignment of territorial management with ecological thresholds.ds.

In the context of emerging paradigms of social development, ecosystemicity provides a balanced, ecology-centered alternative to prevailing economic-dominant approaches, offering a foundation for more resilient and equitable sustainability transitions.

Conclusions

The study finds that SDG monitoring prioritizes economic growth and often fails to track absolute resource use, thereby weakening ecological integrity assessments. A preference for economic expansion may run counter to the requirement to adhere to strict boundaries for physical expansion, which is especially important in developed nations with high levels of resource use and well-being. Findings underscore the need for a holistic approach that balances economic, social, and environmental objectives instead of privileging economic indicators. Achieving this balance requires:

1. Creating and implementing a broader set of measures that capture social and environmental progress beyond economic growth.
2. Ensuring that funds available for sustainable development are allocated to initiatives that yield more than simply financial gains but also the greatest and most pervasive benefits.
3. Promoting a worldwide perspective on sustainability that acknowledges the environment's inherent worth and everyone's well-being, rather than merely using them as a means to a goal.

A genuine sustainability transition must extend beyond numerical SDG targets. It requires embedding ecological integrity, social equity, and shared prosperity at the core of development strategies. Strengthening decentralized, locally grounded approaches to sustainable development will be essential. While the SDGs can serve as useful

frameworks and sources of legitimacy for such efforts, their true transformative potential lies not in meeting numerical targets alone but in driving systemic, paradigm-level shifts toward an ecologically safe and socially just future. Ecosystemicity allows for the consideration of complexities and the fluid nature of relations between SD domains, particularly relevant in coopetition contexts where the lines between competition and collaboration among economic, social, and environmental 'agents' are blurred and constantly evolving. This also implies a new institutional ecosystem, based on "new multilateralism". Using a collective-action lens and a legitimacy-as-process approach, one can develop a process model in which an orchestrator, complementors, users, and external actors collaborate to build ecosystem legitimacy.

References

Ahmed, S. (2021). Social development and the Sustainable Development Goals in South Asia. *Canadian Journal of Development Studies,* 42(4): 592–593. DOI: https://doi.org/10.1080/02255189.2021.1884049.

Alvarez, L., Moreno, J., Aravena, B., King, C. and Heinle, W. (2025). *A green, inclusive, and sustainable development framework for the Amazon region*. IDB. DOI: https://dx.doi.org/10.18235/0013540.

Barbier, E. and Burgess, J. (2021). *Economics of the SDGs: Putting the sustainable development goals into practice.* London: Palgrave Macmillan.

Barron, P., Cord, L., Cuesta, J., Espinoza, S., Larson, G. and Woolcock, M. (2023). *Social sustainability in development: Meeting the challenges of the 21st century*. Washington, DC: World Bank Publications.

Benjamin, N. (2023). *Environmental and social risk management: Pillar of sustainable development*. Abingdon (UK): Our Knowledge Publishing.

Berezovska, N., Zahorskyi, V., Kalashnyk, N., Novak-Kalyayeva, L., Lipentsev, A., Olefirenko, O., Oliyarnyk, V. and Sushynskyi, O. (2024). Implementing an ecosystem approach in public administration: achieving sustainable development goals in crisis and recovery. *Brajects,* 17(se4): 334-347. DOI: https://doi.org/10.14571/brajets.v17.nse4.

Betz, C. and Jung, R. Value Creation in Business Ecosystems – A Design Theory for a Reference Model. *AMCIS 2021 Proceedings. 4*. Available online at: https://aisel.aisnet.org/amcis2021/virtual_communities/virtual_communities/4 [accessed on 22 October 2025].

Binder, C., Hinkel, J., Bots, P. and Pahl-Wostl, C. (2013). Comparison of frameworks for analyzing social-ecological systems. *Ecology and Society,* 18(4): 26. DOI: https://doi.org/10.5751/ES-05551-180426.

Čábelková, I., Smutka, L, Mareš, D., Ortikov, A. and Kontsevaya, S. (2023) Environmental protection or economic growth? The effects of preferences for individual freedoms. *Frontiers in Environmental Science,* 11: 1129236. DOI: https://doi.org/10.3389/fenvs.2023.1129236.

Castro-Arce, K. and Vanclay, F. (2020). Transformative social innovation for sustainable rural development: An analytical framework to assist community-based initiatives. *Journal of Rural Studies,* 74: 45-54. DOI: https://doi.org/10.1016/j.jrurstud.2019.11.010.

Copus, A., Kahila, P. and Fritsch, M. (2022). City region thinking, a zombie idea in regional and rural development? Scotland and Finland compared. *Journal of Rural Studies,* 89: 348-356. DOI: https://doi.org/10.1016/j.jrurstud.2021.11.019.

Dai, G., Zhang, L., Zhang, Q. and Mao, M. (2024). Navigating tensions between value creation and capture in ecosystems. *Journal of Business Research,* 170: 114333. DOI: https://doi.org/10.1016/j.jbusres.2023.114333.

Darling, D. (2021). *World population prospects at the UN: our numbers are not our problem?* Bristol, UK: Bristol University Press.

Eisenmenger, N., Pichler, M., Krenmayr, N., Noll, D., Plank, B., Schalmann, E., Wandl, M.T. and Gingrich, S. (2020). The Sustainable Development Goals prioritize economic growth over sustainable resource use: a critical reflection on the SDGs from a socio-ecological perspective. *Sustainability Science,* 15: 1101–1110. DOI: https://doi.org/10.1007/s11625-020-00813-x.

European Commission (2022). *Global population trends and implications*. Policy Brief. Available online at: https://publications.jrc.ec.europa.eu/repository/handle/JRC129835 [accessed on 22 October 2025].

Fioramonti, L., Coscieme, L. and Mortensen, L.F. (2019). From gross domestic product to wellbeing: How alternative indicators can help connect the new economy with the Sustainable Development Goals. *The Anthropocene Review,* 6(3): 207-222. DOI: https://doi.org/10.1177/2053019619869947.

Hariram, N.P., Mekha, K.B., Suganthan, V. and Sudhakar, K. (2023). Sustainalism: An Integrated Socio-Economic-Environmental Model to Address Sustainable Development and Sustainability. *Sustainability*, 15(13): 10682. DOI: https://doi.org/10.3390/su151310682.

Hessle, S. (2014). *Environmental change and sustainable social development: Social work-social development.* Volume II. London: Routledge.

Horodecka, A. (2023). Is economic development really becoming sustainable? *Forum for Social Economics,* 1–23. DOI: https://doi.org/10.1080/07360932.2024.2401436

Ilic, B. and Dukic, G. (2022). Creating and designing sustainable management on the global level. DOI: https://doi.org/10.55539/jesd.9.1.6.

Jiang, Y., Long, H., Ives, C.D., Deng, W., Chen, K. and Zhang, Y. (2022). Modes and practices of rural vitalisation promoted by land consolidation in a rapidly urbanising China: A perspective of multifunctionality. *Habitat International,* 121: 102514. DOI: https://doi.org/10.1016/j.habitatint.2022.102514.

Kalashnyk, N. and Kyrylenko, P. (2025). From traditional to digital economy: reshaping anti-corruption policies for sustainable development. *SSD Journal,* 10(50): 183-189. DOI: https://doi.org/10.5281/zenodo.15401630.

Ketschau, T. (2017). Social sustainable development or sustainable social development - two sides of the same coin? The structure of social justice as a normative basis for the social dimension of sustainability. *International Journal of Design & Nature and Ecodynamics,* 12(3): 338-347. Available online at: https://www.witpress.com/Secure/ejournals/papers/DNE120306f.pdf [accessed on 22 October 2025].

Li, X., Yang, H., Jia, J., Shen, Y. and Liu, J. (2021). Index system of sustainable rural development based on the concept of ecological livability. *Environmental Impact Assessment Review,* 86: 106478. DOI: https://doi.org/10.1016/j.eiar.2020.106478.

Masterson, V.A., Vetter, S., Chaigneau, T., Daw, T.M., Selomane, O., Hamann, M., Wong, G.Y., Mellegård, V., Cocks, M. and Tengö, M. (2019). Revisiting the relationships between human well-being and ecosystems in dynamic social-ecological systems: Implications for stewardship and development. *Global Sustainability,* 2(e8). DOI: https://doi.org/10.1017/sus.2019.5.

Nagel, B. and Partelow, S. (2022). A methodological guide for applying the social-ecological system (SES) framework: a review of quantitative approaches. *Ecology & Society,* 27(4): 39. DOI: https://doi.org/10.5751/ES-13493-270439.

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science,* 325(5939): 419–422. DOI: https://doi.org/10.1126/science.1172133.

Partelow, S., Fujitani, M., Soundararajan, A. and Schulter, A. (2019). Transforming the social-ecological systems framework into a knowledge exchange and deliberation tool for comanagement. *Ecology and Society,* 24(1). DOI: https://doi.org/10.5751/ES-10724-240115.

Preiser, R., Pereira, L.M. and Biggs, R.O. (2017). Navigating alternative framings of human-environment interactions: variations on the theme of 'Finding Nemo.' *Anthropocene,* 20: 83–87. DOI: https://doi.org/10.1016/j.ancene.2017.10.003

Rotondo, F., Perchinunno, P., L'Abbate, S. and Mongelli, L. (2022). Ecological transition and sustainable development: integrated statistical indicators to support public policies. *Scientific Reports,* 12*:* 18513. DOI: https://doi.org/10.1038/s41598-022-23085-0.

Sarvajayakesavalu, S. and Chareonsudjai, P. (2021). *Environmental issues and sustainable development.* London: IntechOpen.

Scholz, R.W. and Binder, C.R. (2011). The HES Framework. In: R. Scholz (ed.), *Environmental literacy in science and society: from knowledge to decisions* (pp 453–462). Cambridge, UK: Cambridge University Press.

Sedovs, E., Volkova, T. and Ludviga, I. (2025). Sustainable development and strategic management - what is on the horizon in our non-ergodic world research? *Sustainable Futures,* 9: 100414. DOI: https://doi.org/10.1016/j.sftr.2024.100414.

Singh, B. and Batar, A. (2024). *Sustainable local development for environmental and social sustainability*. London: Springer.

Tidball, K.G., Metcalf, S., Bain, M. and Elmqvist, T. (2018). Community-led reforestation: cultivating the potential of virtuous cycles to confer resilience in disaster disrupted social–ecological systems. *Sustainability Science,* 13(3): 797-813. DOI: https://doi.org/10.1007/s11625-017-0506-5.

Turnbull, J.W., Clark, G.F. and Johnston, E.L. (2021). Conceptualising sustainability through environmental stewardship and virtuous cycles - a new empirically-grounded model. *Sustainability Science,* 16: 1475–1487. DOI: https://doi.org/10.1007/s11625-021-00981-4.

Wu, Q., Jiang, X., Song, M., Liu, Y., Shi. X., Lei, Y. and Nie, T. (2023). Study on the development trend of social-ecological systems and the drivers of sustainable development – A case study of the Loess Plateau in China. *Ecological Indicators,* 156: 111172. DOI: https://doi.org/10.1016/j.ecolind.2023.111172.

Wu, J., Addai, J., Cansolata, M., Gao, Z., Martin, E., Yasutake, E. and Wang, Y. (2025). Landscape sustainability science and the Sustainable Development Goals. *Geography and Sustainability,* 6(5): 100309. DOI: https://doi.org/10.1016/j.geosus.2025.100309.

Wyrwa, J., Jędrzejczak-Gas, J., Barska, A. and Wojciechowska-Solis, J. (2023). Sustainable energy development and sustainable social development in EU countries. *Energies,* 16(18)L: 6556. DOI: https://doi.org/10.3390/en16186556.

Xu, W. (2024). Innovative development of territories based on the integrated use of social, resource and environmental potential. *Scientific Reports,* 14: 29233. DOI: https://doi.org/10.1038/s41598-024-80876-3.

Zahorskyi, V., Sushynskyi, O., Kalashnyk, N., Novak-Kaliaieva, L. and Oliyarnyk, V. (2024). Analytical materials for the National Report on the State of the Environment in Ukraine in 2023 (public and administrative aspect). *Public Administration and Local Self-Government,* 2: 36–45. DOI: https://doi.org/10.32782/2414-4436/2024-2-5.

Doi: https://doi.org/10.33002/nr2581.6853.080314 Open Access

Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*	*Author 3*	*Author 4*	*Author 5*	*Author 6*	*Author 7*	*Author 8*
Conceived and designed the research or analysis	No	Yes	No	Yes	Yes	Yes	No	Yes
Collected the data	No	Yes	Yes	Yes	Yes	No	No	Yes
Contributed to data analysis & interpretation	Yes	Yes	No	No	Yes			
Wrote the article/paper	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Critical revision of the article/paper	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Editing of the article/paper	Yes	Yes	Yes	No	No	No	No	No
Supervision	Yes	No	Yes	Yes	No	Yes	No	No
Project Administration	No	Yes	Yes	Yes	No	No	No	No
Funding Acquisition	No	No	No	No	No	No	No	No
Overall Contribution Proportion (%)	20	20	10	10	10	10	10	10

Funding
No funding was available for the research conducted for and writing of this paper.

Research involving human bodies or organs or tissues (Helsinki Declaration)
The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

Research involving animals (ARRIVE Checklist)
The author(s) solemnly declare(s) that this research has not involved any animal subject (body or organs) for experimentation. The research was not based on laboratory experiment involving any kind animal. The contexts of animals were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of ARRIVE does not apply in cases of this study or written work.

Research on Indigenous Peoples and/or Traditional Knowledge
The author(s) solemnly declare(s) that this research has not involved Indigenous Peoples as participants or respondents. The contexts of Indigenous Peoples or Indigenous Knowledge were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or prior informed consent (PIC) of the respondents or Self-Declaration in this regard does not apply in cases of this study or written work.

Research involving Plants
The author(s) solemnly declare(s) that this research has not involved the plants for experiment and field studies. Some contexts of plants are also indirectly covered through literature review. Thus, during this research the author(s) obeyed the principles of

the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

Research Involving Local Community Participants (Non-Indigenous) or Children
The author(s) solemnly declare(s) that this research has not directly involved any local community participants or respondents belonging to non-Indigenous peoples. Neither this study involved any child in any form directly. The contexts of different humans, people, populations, men/women/children and ethnic people were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or prior informed consent (PIC) of the respondents or Self-Declaration in this regard does not apply in cases of this study or written work.

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
The author(s) has/have complied with PRISMA standards to an extent.

Competing Interests/Conflict of Interest
Author(s) has/have no competing financial, professional, or personal interests from other parties or in publishing this manuscript. There is no conflict of interest with the publisher or the editorial team or the reviewers.

Attribution and Representation
All opinions and mistakes are the author(s)' own and cannot be attributed to the institutions they represent. The publisher is also not responsible either for such opinions and mistakes in the text or graphs or images.

Declaration of the Use of AI
During the preparation of this work, the authors used AI to assists the script translation, language editing, grammar correction, reference management, improving readability and proof reading. The author(s) declared that the use of AI has not compromised originality, leading to plagiarism, or violating data privacy and copyright. Author(s) is/are responsible that AI use complies with ethical standards of research and publication. It is also declared that AI-generated content fabricating data, references or findings is strictly avoided and not included. Author(s) adhered the AI's upper usage limit of 15% as fixed by the journal.

Rights and Permissions

Open Access. This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third-party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.

***

To see original copy of these declarations signed by Corresponding/First Author (on behalf of other co-authors too), please download associated zip folder [Declarations] from the published Abstract page accessible through and linked with the DOI: https://doi.org/10.33002/nr2581.6853.080314.